The Sar-Grav Laboratory

D. D’Urso on behalf of the Sar-Grav Team
Former mine with underground access guaranteed through tunnels and shaft

Credits to L. Naticchioni
The SarGrav Laboratory

Founded with 3.5 M€ by the Regione Autonoma della Sardegna (RAS) to host low seismic noise underground experiments (low seismic noise experiments, cryogenic payloads, low frequency and cryogenic sensor development)

- ~ 900 m² surface Laboratory
- 3 Underground stations equipped for measurements at different depths
- ~ 50 m² underground area available
- planned a 250 m² underground Lab
- First experiment: Archimedes (founded by INFN)
Sar-Grav Management Structure

Executive Board (EB)
- M. Carpinelli (Chair), UniSS delegate
- S. Falciano, INFN delegate
- G. Saccorotti, INGV delegate
- M. Caria, IGEA delegate
- 2 RAS delegates

Technical-Scientific Board (TSB)
- F. Ricci (Chair, La Sapienza University)
- G. Saccorotti (INGV)
- D. D’Urso (UniSS)
- 1 RAS delegate

D. D’Urso - GWADW 21 - May 17-21 2021
Current Activities

➢ Experimental activities

➢ Underground Lab excavation

➢ Infrastructure enhancement

➢ Site monitoring and support for ET Site Characterization studies
Experimental activities
First Experiment: Archimedes

- Experimental Goal: measurement of the interaction between vacuum fluctuations with gravity weighting a Casimir multi-cavity while changing the reflectivity of its layers. A change in the reflectivity corresponds into a variation of the internal vacuum state energy.

- Apparatus: high sensitivity balance working in cryogenic conditions (~90 °K)

- High-T<sub>c</sub> superconductors (i.e. YBCO) as natural Casimir multi-cavities;
- Measurements taken in HV (10<sup>-8</sup> mbar) at cryogenic temperature (T = T<sub>c</sub> ≈ 90 K);
- Reflectivity changed via thermal actuation;
- Flexible thin joints with low thermal noise;
- Two suspended arms to apply coherent noise subtraction;
- Interferometric read-out system;
- Feedback control;
- Low seismic noise site.
Prototype Balance and Inner Cryostat installed @ Sos Enattos

- Prototype test at lower frequencies (June 2021)
- Shipping and installation of the final balance (June – July 2021)
ARCHIMEDES for ET: the tiltmeter

- Quality check of the site with a fundamental physics experiment
- Direct tilt measurement from 2 Hz to 20 Hz (region of interest for ET): best sensitivity in the world for a tiltmeter in the region 2 Hz – 20 Hz (paper In preparation)
- At our knowledge Sos Enattos has shown the lowest tilt noise ever measured
Underground Lab Excavation
Underground 3D model

See talk by M. Marsella
Session “Third Generation Infrastructures”
The feasibility study preceding the final design has been completed

- 3D modelling
- Rock characterization analysis
- Modelling of the excavation and consolidation phases
- Geometry of lab and service areas have been defined
- Technological and safety infrastructures have been defined

Next step: Start of the procedure for contracting the construction
Infrastructure Enhancement
Surface Laboratory

- 3D model
- Structural studies
- Optimization of space
Infrastructure Enhancement

- A plan to equip Sar-Grav lab with additional facilities by the 2021 has been already founded by the RAS
  - Mechanic Lab equipped with a 20 tons crane
  - Clean Room
  - Data storing and management system
  - Nitrogen liquefier
  - Fiber network link (1 Gbps)

- Additional small underground area for experiments, equipped with power, gps and fiber link, will be set up
Clean Room

- **Zona 1 Lab. E SAS ISO B, Classe 1000** (35 m², Vol. 87.5 m³)
- **Zona 2 Clean Room ISO C, Classe 10000** (25 m², Vol. 100 m³)
20 t Crane
Work already on going

New Experimental area in preparation
Site monitoring and support for ET Site Characterization studies
Site monitoring and characterization

- Measurement stations
  - SarGrav surface Lab
  - SOE0 (surface)
  - SOE1, SOE2, SOE3 (-86 m, -111 m, -160 m)

- Sensors on site
  - 4 broadband triaxial seismometers;
  - 5 short-period triaxial seismometers (first seed of a new array);
  - 2 magnetometers (1 buried at surface, 1 underground);
  - High precision tiltmeter (Archimedes prototype)
  - Weather station

- New sensors expected to be installed in the next months (seismometers, geophones, microphones, magnetometers)

- Data acquired at the SarGrav control room, transmitted via UMTS link to remote server (INGV-PI server → ET repository), and accessible through an INFN access point.

See talk by L. Naticchioni
Session “Third Generation Infrastructures”
Measurement stations

Sos Enattos measurement stations (since Aug. 2020)

- SarGrav surface lab
- SOE0 (surface)
- SOE1, SOE2, SOE3 (-84m, -111m, -160m)

- integrated into the INGV seismometer network

http://cnt.rm.ingv.it/en/instruments/station/SENA

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See talk by L. Naticchioni
Session “Third Generation Infrastructures”
Site Characterization and monitoring

- Long-term seismic and environmental monitoring
- First year of seismic characterization measurements at Sos Enattos published
  - SRL 2020, [https://doi.org/10.1785/0220200186](https://doi.org/10.1785/0220200186),
  - EPJP 2021, [https://doi.org/10.1140/epjp/s13360-021-01450-8](https://doi.org/10.1140/epjp/s13360-021-01450-8)
- In the 1-10Hz is among the quietest sites in the world
- Very low environmental noise
Conclusions and perspectives

- SarGrav Lab is a very low noise infrastructures, designed to host low seismic noise experiments, cryogenic payloads, low frequency and cryogenic sensor development

- The Archimedes use case will allow assess the site quality and to verify how to implement underground cryogenic and vacuum systems without degrading the site

- Experimental activities:
  - preliminary experimental tests to assemble Archimedes components
Conclusions and perspectives (2)

- Underground excavation
  ✓ feasibility study preceding the final design completed
- Enhancement plan of surface infrastructures
- Site Monitoring: synergy with ET Characterization Activities and support in terms of logistics and manpower
- SarGrav Lab will host ET technology prototypes to test them in the same ET expected noise conditions
See you soon in Sardinia
Low Seismic Noise Site
One of the least populated areas in EU

European continental landmass: seismically quiet
Prototype @ low frequency

Commissioning on June 2021

- Diffused light
- Substitution of actuator power supplies
- Software optimization for low frequency control
- Installation of vacuum valve to operate without pump noise (from EGO Vacuum group)

Low frequency sensitivity obtained @EGO
Laser scanning for geo-structural surveying

- Rock discontinuities identified by the dense laser point cloud
- Laser scans at different orientations and position along the galleries
- segmentation
- Semi automatic (supervised) plane extraction
- Set parameters for rock kinematic stability analysis
Toward the cavern design
Interference Analysis

A. Paoli @ 10th ET symposium

INTERFERENCE ANALYSIS
Protected areas – Regional and National Parks

INTERFERENCE ANALYSIS
Geo-Mining Parks

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Sos Enattos site qualification

A. Paoli @ 10th ET symposium

Crustal Deformation and Ground Motion
DInSAR Analysis

- Very stable geodynamic setting
- No evidence of ground settlements due to local factors
- Link to the Space Geodesy Center in South Sardinia for reference frame issues
Preliminary geological and geotechnical characterization of the Sos Enattos ET site

Prof. Giacomo Oggiano
Dr. Stefano Cuccuru

Giugno 2019

Fig. 35. Resistivity tomography of Bitti granite.